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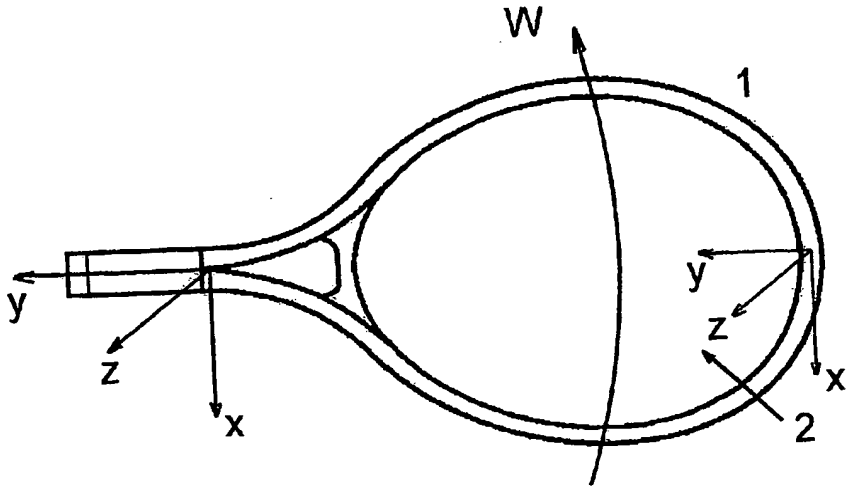
(54) Title: METHOD FOR MEASURING PARAMETERS AND A STRIKING DEVICE



(57) Abstract: The invention relates to a method for measuring and computing of a striking device, such as a tennis racquet. The velocity of the striking device is determined by measuring the acceleration in at least one direction, preferably a centripetal direction, and computing said velocity from said acceleration.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method for measuring parameters and a striking device

The invention relates to a method for measuring and computing parameters upon striking an object to be moved, such as a ball, at a hitting location on a striking surface of a striking device, such as a tennis racquet, in which at least one sensor system comprising at least one sensor, which system is attached to the striking device, delivers signals to a computer, which computes at least the velocity of the object being moved and/or the velocity of the striking device from said signals, which velocity is presented on one or more presentation devices.

US patent No 6,134,965 describes an apparatus for deriving a parameter, in particular the velocity at which a ball is being struck, i.e. the sum of the velocity of the ball and the velocity (in opposite direction) of the racquet, from the vibrations of the racquet strings.

German Patentschrift No 34 36 218 describes an apparatus for counting the number of strokes with a striking device, which apparatus comprises a contact foil that is present in or near the striking surface of said striking device.

European patent application No 0 407 631 discloses a method for testing that tennis racquet.

The object of the method according to the invention is to improve the method referred to in the introduction, and to that end it comprises the features defined in claim 1 or claim 2. The invention makes it possible to determine the velocity of the striking device itself during a swinging movement and/or at the time of an impact by measuring the acceleration, in particular the acceleration in centripetal direction.

Preferably, an enumeration both the overall number of strokes and of the number of good and bad strokes that have been played is given when using the method according to the invention for the purpose of improving the player's performance, to which end this preferred method is characterised

in that the sensors measure the acceleration of the swing of the striking device and register whether an impact with the ball takes place on the front side or on the rear side of the striking device.

From US patent No 5,816,580, for example, there is known a paddle having a striking surface on either side, on which a sensor is present for measuring the impact with a bat and delivering a relevant signal to a counter. The intention of the game is to return the ball while using a different side for each stroke. The counter registers that a mistake has been made, in which case the opponent scores a point. This registration thus has nothing to do with games in which it is the game position that determines whether to use a forehand or a backhand stroke.

In a further development of the method according to the invention, not only the acceleration but also the magnitude and the frequency of the vibrations caused by the impact in at least one direction, preferably in two or three directions perpendicular to each other, are measured in order to determine which impact position on the striking surface causes the lowest amplitude vibrations and is thus the most effective.

The invention furthermore comprises a striking device, such as a racquet, a bat or a stick in accordance with claims 6 - 8.

Preferably, the accelerations experienced by the sensor are fed to a computer in the form of as many signals during each of the successive strokes, which computer is connected to a presentation device, on which the changes in the acceleration during the swing and upon impact during said successive strokes can be displayed. In this way it is possible to provide the player with accurate information as to his good and his bad shots, which will enable him to adapt his technique in a positive sense.

It is noted that from US patent No 5,351,952 there is known a method for matching golfer to golf club, in which the swing time of a golfer is measured is and a golf club having the inverse of four times its natural frequency ap-

proximately equal to the golfer's measured swing time is selected for the golfer.

The invention makes it possible, depending on the specific embodiment, to take into account a number of important factors, such as velocity and acceleration of the striking device, the spatial direction of the striking device as a function of the direction in which the object to be moved hits the striking surface of the striking device and the angle of the striking device relative to the hitting location.

The above and further aspects of the invention will be explained in more detail hereinafter with reference to the figures, which show an example of one of the possible methods and apparatuses according to the invention.

Fig. 1 shows a tennis racquet in the forehand position, which racquet comprises a housing formed on or in the handle, which housing accommodates a sensor system.

Fig. 2 is a schematic representation of the electronic processing of the received signals.

Fig. 3 is a graphic representation of centripetal forces and the impacts of the ball on the racquet.

Fig. 4 is a graphic representation which shows the vibrations on the racquet in the case of a "good" hitting location and in the case of a "bad" hitting location.

The tennis racquet 1 comprises a striking surface 2 consisting of strings, whose front side or rear side can be used for hitting a ball, the choice between the two sides being determined by the game position. To that end, the racquet undergoes a swinging movement W, in this case drawn in the position in which the front side of the striking surface is used, during which movement the racquet experiences a centripetal force. The magnitudes of the accelerations that occur in the X-, Y- and Z-directions are measured by a sensor system 3, which is mounted in or near the handle of the tennis racquet 1 or, preferably, in or near the tip of the tennis racquet 1. The sensor system comprises one or more piezoelectrical accelerometers and delivers corresponding signals to a computer, for example a microcomputer accommodated in the handle, which is connected, either by means of a signal

conductor or wirelessly, to a remote presentation device (not shown), such as a display screen, an X-Y writer or the like, or to a mini screen or the like mounted on the racquet.

Since the acceleration, in particular in the "Z"-direction can reach a value of 2000 G, whereas only small accelerations (about 2 G) occur for registering the hitting locations or position changes from forehand to backhand, it is preferable to use separate sensors, whose degree of sensitivity is geared to accommodate said extreme differences in the acceleration values.

Figure 2 schematically indicates the electronic path along which the signals from the three acceleration sensors 3x, 3y, 3z are supplied, via signal amplifiers 4 and an analog/digital converter 5, to a microprocessor 6, which is connected to a storage/memory 7 on the one hand and to a presentation device, such as a PC 8, on the other hand. Control buttons 9 can be used for making a selection from the various images that are to be displayed, for example after a match or after a series of strokes.

The signals being received are converted in the computer, so that the following information can be provided on the presentation device:

- the interval of time between the successive strokes;
- the velocity of the racquet prior to hitting the ball;
- forehand or backhand;
- service stroke (yes, no) and velocity of the service;
- the maximum amplitude of the vibrations;
- the maximum acceleration in the "Z"-direction (a measure of the velocity of the ball);
- the hitting location of the ball on the striking surface of the racquet;
- the number of strokes per unit time;
- the total number of strokes;
- indications "in" or "out".

This information enables the player or the trainer to get an impression of the quality of the player's game by analysing a large number of different technical aspects and furthermore to find out which techniques of the game require adaptation or improvement.

The forces along the three axes Cx, Cy, Cz as well as the impacts B are schematically and graphically represented in Fig. 3, which clearly shows the magnitudes of the various accelerations associated with said successive impacts. The rotational speed of the tennis racquet 1 about an effective centre of rotation, which is e.g. located between the player's wrist and elbow, can be determined on the basis of the centripetal force Cy.

Fig. 4 clearly shows the difference between a stroke that generates strong vibrations, which occurs when the ball hits a striking surface at an incorrect position thereon, and a stroke that generates relatively mild vibrations, which occurs when the ball hits the striking surface at a correct position thereon.

Using the game data that can be obtained by means of the apparatus according to the invention, it is possible to combine the timing data with the acceleration data. All kinds of information/conclusions can be derived on the basis of heuristics by measuring the interval of time between successive strokes. Assuming, for example, that the player is serving and the ball is out, it is practically certain that the player will hit a new service within 3 to 5 seconds, without other types of strokes being hit in the meantime. In other words: all kinds of conclusions can be drawn on the basis of knowledge of the game (the rules), the types of strokes and heuristics. In the aforesaid case, for example, it is readily possible to determine precisely the number of first services that were in, the difference in velocity between the first and the second services and the number of services directed at the opponent's forehand and backhand, respectively, after the game. (Player A serves, player B receives the ball one-tenth of a second later).

Furthermore it is for example possible to combine the data registered by one of the sensor systems according to the invention, which are attached not only to the bat but also to the wrist or the hand of a baseball pitcher, and the angular displacements and accelerations and parameters further derived therefrom.

In this way it is for example possible to measure what kind of pitch shots (velocity and type of effect) are proving to be the most difficult for the batsman.

Furthermore it is possible, of course, using the apparatus according to the invention, to have the computer give the player directions (so-called direct teaching), e.g. by means of an acoustic signal, during a game or during a training session.

The methods according to the invention enable the sporters to train more efficiently. For example, they may be instructed to pay some extra attention to their backhand service return during a training session.

The coaching or training information might also be communicated during the training session by means of a speech generating module connected to the computer. The computer and the speech generator might operate separately from the bat or be integrated therein.

It stands to reason that if the position of the racquet relative to the court is also registered, the location where the ball will hit the court can be computed in an acceptably precise manner on the basis of the velocity of the ball in combination with the location where the ball makes contact with the racquet, whilst it can also be derived from said measured place on the court whether the ball was in or out and, for example, whether the ball has been played with topspin.

The method according to the invention makes it possible to store the above and other game situations in the memory of the computer and visualise these data at any desired moment, for example for evaluating a training session or a match.

CLAIMS

1. A method for measuring and computing parameters upon striking an object to be moved, such as a ball, at a hitting location on a striking surface of a striking device, such as a tennis racquet, in which at least one sensor system comprising at least one sensor, which system is attached to the striking device, delivers signals to a computer, which computes at least the velocity of the object being moved and/or the velocity of the striking device from said signals, which velocity is presented on one or more presentation devices, wherein the acceleration of the striking device during a swinging movement and the impact with the object to be moved is measured in at least one direction, and wherein at least the velocity of the object being moved and/or of the striking device is derived from said measurement, for example by means of a computer or the like.

2. A method for measuring and computing parameters upon striking an object to be moved, such as a ball, a shuttle or a puck, at a hitting location on a striking surface of a striking device, such as a tennis racquet, a badminton racquet, a squash racquet, a table tennis bat, a cricket bat, a hockey stick or the like, in which at least one sensor system comprising at least one sensor, which system is attached to the striking device, delivers signals to a computer, at least upon making contact with the object to be moved, which computer computes at least the velocity of the object being moved and/or the position of the hitting location on the striking surface from said signals, which velocity and/or position is presented on one or more presentation devices, such as a panel, a sheet or a screen, wherein the acceleration of the striking device during the swinging movement and/or upon impact with the object to be moved is measured in at least one direction, preferably two or three directions perpendicular to each other, from which measurement the velocity of the object being moved and/or the acceleration of the striking device is derived, for example by means of a computer or the like computing device, and displayed on a presentation de-

vice, which process is preferably repeated upon measurement of successive strokes, with the result being displayed in the form of a graphic illustration and/or a statistical diagram, preferably also taking into account the measured interval of time between the strokes and the changes in the velocity during said successive strokes.

3. A method according to claim 1 or 2, wherein the sensors measure the acceleration of the swing of the striking device and register whether an impact with the ball takes place on the front side or on the rear side of the striking device.

4. A method according to any one of the preceding claims, wherein the number of strokes carried out with the striking device, both in the case of an impact with the object to be moved on the rear side and in the case of an impact on the front side, are registered and presented.

5. A method according to claim 1 or 2, wherein the sensor system, in addition to measuring the acceleration, also registers vibrations that occur in the hitting area and transmits signals comprising information on the amplitude and the frequency of said vibrations to the computer, which computes the position of the hitting location on the striking surface that causes the lowest amplitude vibrations upon impact with the object to be moved.

6. A striking device, such as a racquet, a bat or a stick, comprising at least one sensor system attached to the striking device for delivering measuring signals upon movement of the striking device and/or upon impact of an object to be moved with a striking surface present on at least one side of the striking surface, wherein the sensor or sensors of said sensor system is (are) arranged for measuring the magnitude of accelerations in three directions perpendicular to each other, which sensor system is connected to a computer (likewise attached to the striking device) for the purpose of delivering signals thereto, which computer functions to determine the velocity of the striking device at the time of said impact and the velocity of the object to be moved after said impact, which values can be displayed on one or more

presentation elements, such as a display screen, a paper strip or the like.

7. An apparatus for carrying out the method according to claim 1 or 2, comprising a striking device, such as a racquet, a bat or a stick, and at least one sensor system attached to the striking device for delivering measuring signals upon impact of an object to be moved with a striking surface present on at least one side of the striking device, wherein the sensor or sensors of said sensor system is (are) arranged for measuring the magnitude of accelerations in one direction, or preferably in two or three directions perpendicular to each other, which sensor system is connected to a computer (likewise attached to the striking device) for the purpose of delivering signals thereto, which computer functions to determine the velocity of the striking device and/or of the object to be moved after said impact, which values can be displayed on one or more presentation elements, such as a display screen, a paper strip or the like.

8. An apparatus for carrying out the method according to claim 1 or 2, comprising a striking device, such as a racquet, a bat or a stick, and at least one sensor system attached to the striking device for delivering measuring signals upon impact of an object to be moved with a striking surface present on at least one side of the striking device, wherein said sensor system is arranged for measuring the magnitude of accelerations in one direction, or preferably in two or three directions perpendicular to each other, which sensor system is connected to a signal amplifier for delivering generated signals thereto, and wherein a connecting element is present for transmitting said signals to a computer remote from the striking device, which computer functions to derive information, such as the velocity of the object to be moved after the impact with the striking device, from said signals, which information can be displayed on one or more presentation elements, such as a display screen, an X-Y writer, a paper strip or the like.

9. An apparatus according to any one of the claims 5 - 8, wherein said striking device is provided with a striking

surface both on its front side and on its rear side, and wherein said sensor system is arranged for delivering signals that relating to accelerations during the swing of the striking and to the impact with the object to be moved.

10. An apparatus according to any one of the preceding claims 5 - 9, wherein at least one of the sensors of the sensor system that are sensitive to the X-, Y- and Z-directions is sensitive to relatively high G-values and/or at least one of said sensors is sensitive to relatively low G-values.

ABSTRACT OF THE DISCLOSURE

The invention relates to a method for measuring and computing of a striking device, such as a tennis racquet. The velocity of the striking device is determined by measuring the acceleration in at least one direction, preferably a centripetal direction, and computing said velocity from said acceleration.

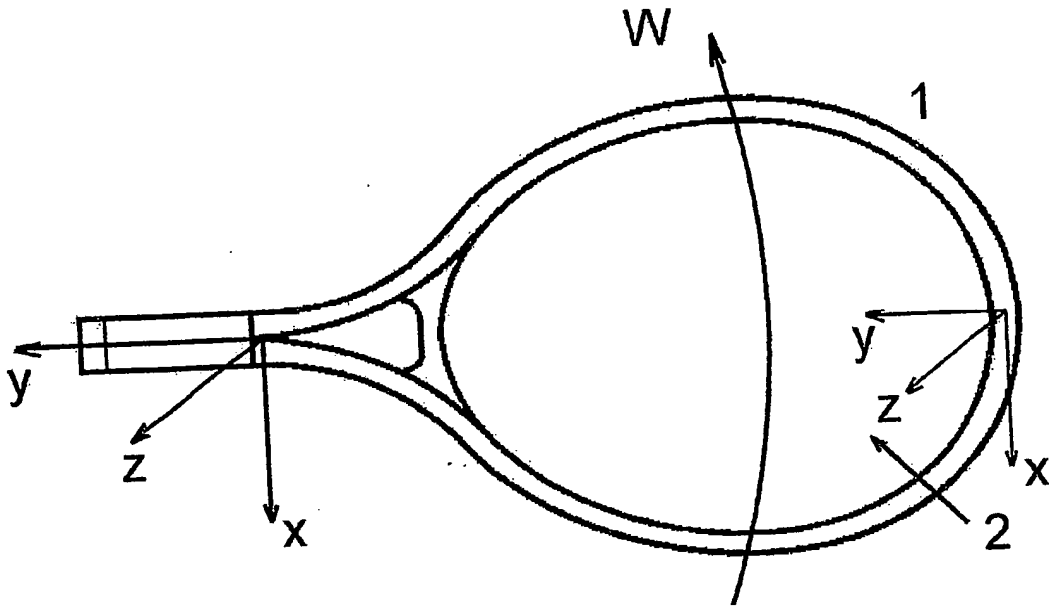


Fig. 1

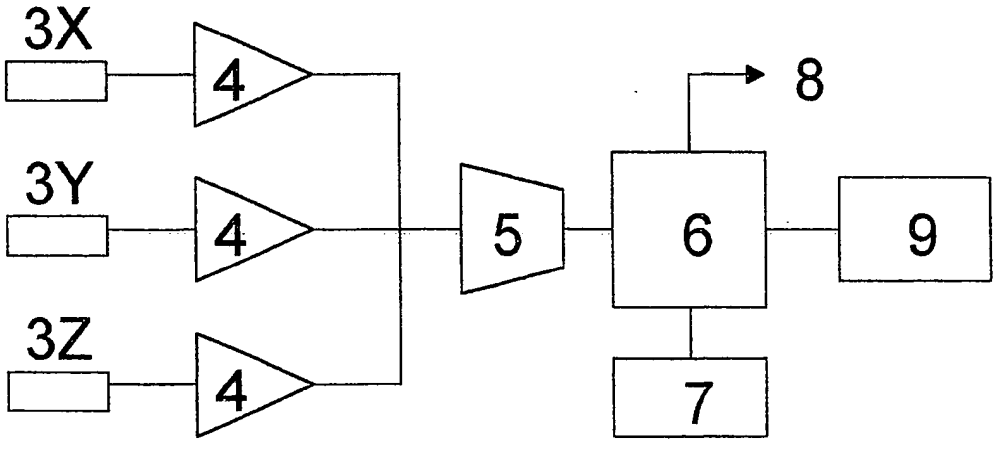


Fig. 2

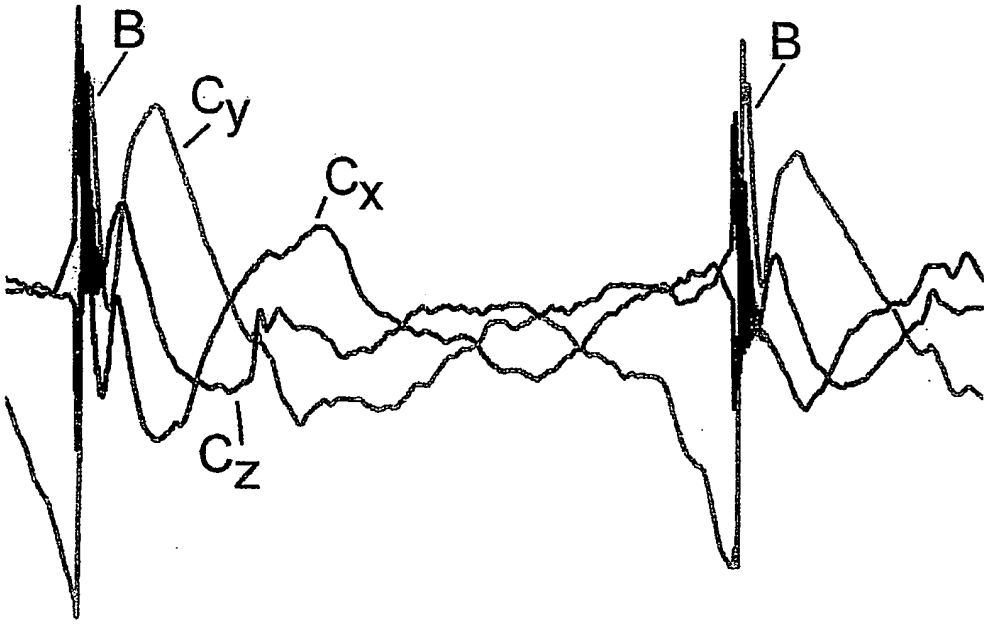
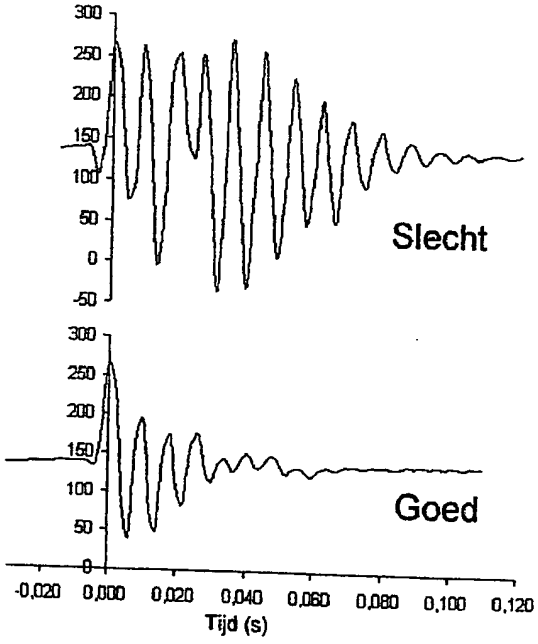

B
Cy
Cx
Cz
B

Fig. 3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Tijd (s)

Fig. 4